

Short Knifonium manual

General notes

Tubes are nasty beasts. Their lifetime can only be statistically evaluated, and sometimes even new tubes fail. Some will last for 5000 hours, some 20000. But eventually they get too weak to work properly. Some fail due to internal short circuits and may cause collateral damage, but Knifonium has been designed to avoid them as much as possible. The oscillator tubes in Knifonium are particularly sensitive to ageing, and I would not expect them to perform necessarily well for more than 1000 hours. Time will tell. This batch of instruments saw a radical modification in the circuits to increase their stability and life compared to first batch.

I designed Knifonium to include as little hard to get tubes as possible, but some types are not trivial. Oscillator tubes are not more manufactured and not all of the old ones are good for Knifonium. We have now over 800 oscillator tubes in stock, and 1200 more are on their way to the workshop soon. I will test and run them in and stock for replacements. Because of their peculiarities I have to be able to provide spares for the whole lifetime of every Knifonium and that is what I intend to do.

Another important tube, no longer made, is the filter tube. They will last much longer than oscillator tubes, but since they should be fairly well matched I intend to keep a stock of over 1000 units.

VCA tubes, output tube, double diodes, all of them also no more made, but less problematic. I will keep reasonable amounts in stock.

There are some calibration operations which should be performed fairly regularly, because when tubes age their properties change. And then there are some, which probably never have to be touched again.

Many of the modulation routings are switched either from source or from destination. This may take some time to get used to. For example LFO is switched at destination but After touch has routings on either end. The reasons for this arrangement are both technical and usability related

Power supply has a delay circuit. After about 30 seconds one can hear a relay click and all the high voltages ramp up. After this it takes a couple of seconds for the synth to start working properly.

Warm up time is roughly 20 minutes. During this time pitch will go up about 10-20 cents, and small changes in pitch happen for longer periods. Octaves are somewhat narrow first, in the order of 2 cents per octave. As oscillator tubes age their tuning will change, both in pitch and octave size, and recalibration is necessary.

This tuning drift is caused by the two oscillator tubes and the semiconductor based exponential converters. After the 20 minutes period the synth is quite stable in tuning. Some of the oscillator tubes (5696) are inherently not very stable though, and some specimens may become unstable later.

We have run in all oscillator tubes for days and chosen the stable ones. This does unfortunately guarantee that they could not go bad after short time, only that they probably last long.

The slide switches do collect some dust and oxidation over time. The less you use them, the more they malfunction. Have a contact cleaner spray available. One day you will need it.

Many tube types have different European, military-industrial and US designations. Here is the list for Knifonium's tube equivalents:

5696 has no equivalents, also 5696A is not suitable.

ECC88=E88CC=6922=6H23 etc

12AX7=ECC83, ECC803 etc

6AL5=5726

2D21=GL2D21=5727

ECC189=6ES8=CV5331

E99F =6BJ6

E81L=6686

Looking from the left the first two tubes (5696) are the oscillator tubes. These are tested and graded by us. The oscillators work as sawtooth generators. The waveform is however not 100% perfect. There is a short period, deionization time, which produces a delay of about 30us after each period.

The deionization time affects scale accuracy, and this is likely to change somewhat when the tubes age. Without compensation circuits every octave would be more narrow than the one below it. In other words the deionization time screws the top octaves more. There are trimmers on the back of the instrument for adjusting the necessary compensation. More on this below.

Oscillator amplitude affects general tuning and sine waveforms (adjustable). More below.

The next two tubes are ECC88 (6922) buffers, and these tubes should not have any grid leak. A leaky tube will cause tuning problems, for example unusual drift and bass being out of tune with higher octaves. We built a test rig for these tubes and the spare 6922 tubes provided are good for any position in the synth.

Next tubes are not very critical.

2D21 is the noise source. Some tube specimens may be problematic here. They may not start to generate noise before the magnet is rotated back and forth. Any tube specimen can be made to work here, but not all will start the noise without tweaking. This is of course highly impractical and the tubes provided have been tested to start generating noise without tweaking. The position of the magnet may later need some adjusting, and a new tube may also need a bit magnet tweaking.

Be careful with the magnet, it is very strong.

ECC189 (CV5331) tubes form the filter ladder, they should have fairly good internal balance. I recommend the supplied CV5331 tubes, but any European manufactured ECC189 works. I can not recommend any American 6ES8, because they often are out of specifications.

E99F tubes form the VCA. They should be a matched pair.

E81L is output tube. Not critical.

How to change tubes?

This is fairly easy. Turn the power off, of course. Wait a couple of minutes. Remove lid. You need a hex key for the screws.

Tubes with a cover: gently push the cover down, then turn counterclockwise to release. A spring inside the cover will usually lift the cover. If you are changing the noise tube be aware that the magnet is strong, don't let the cover+magnet smash into something magnetic.

All tubes: Removing and inserting tubes is much easier with a rocking motion. Don't try to simply push or pull only, add some small rocking or circulating motion and you need less force.

When to power down?

Tubes age, replacing is not fun, so it makes no sense to leave the synth on for extended periods of time. Basically switch it off if you don't need it for hours and if tuning drift after turning on is not a problem.

Power supply

Power supply has a delay circuit. After about 30 seconds one can hear a relay click and all the high voltages ramp up. There are 7 fuses inside, which protect against failures in the supply or in the synth. However, sometimes fuses do fail without any external causes, so it might some day happen that one has to check the fuses if the synth does not work. Open the front lid, not the one with the connector and switch. Always wait at least 5 minutes before opening the lid after power down so that high voltage supplies have time to recharge. Note that there was a print error. Instead of 160mA there is 150mA print. 150mA fuses do not exist. All fuses are slow blow types.

There are two AC 6,3V sources for heaters (without fuses, one of them elevated to 120V inside the synth), one DC 6V for oscillator tube heaters (elevated to 60V inside the synth) one DC 12V source for heaters, +/- 18V sources for all the IC stuff, +200V, +120V and -100V sources for tube electronics.

Power supply is of course safety grounded and the whole synth's 0V ground is connected to earth ground too. Never ever modify this. Always connect to earthed mains. Since the synth has a floating transformer coupled output, it can be connected to any proper system without audible hum.

Oscillator tuning

What to expect? We are talking about analog electronics and especially tube electronics. Therefore things will drift a bit over time and temperature, and actually even powering down and up again may cause tubes to behave just a little differently. However it is possible to calibrate Knifonium to almost exact scale accuracy in the range of 40Hz to 4kHz and short time (24 hours) drift is usually in the order of 20 cents.

Things I have noticed: Extreme bass is a bit problematic. This is tube dependent, but most oscillator tubes cause the lowest notes in 32 foot range (about 32Hz to 45Hz) to be 1-10 cents too high. The lower, the worse. Some tube specimens are almost perfect, but they are not very common, and therefore at least 5 cents deviation in lowest C has to be accepted.

Extreme treble is problematic too, for two reasons. One is the deionization time. 30 microseconds is a lot of time when we are talking about high pitched notes, and even 1us change will be heard at 2kHz. If you have to have absolute accuracy for some time at over 1kHz range, it can be done, but it will not remain perfect for days. Luckily it is fast to adjust once you learn it.

Another problem in the treble is that since current through oscillator tubes is high there, they do warm up more and this changes the tuning a little bit. This makes it probably impossible to jump from low bass to high treble without some change in the pitch. Now we are talking about 5 cents perhaps, not more. So, when changing the range of music, allow a minute for stabilization and trim the pitch if needed.

There are a couple of trimmers for each oscillator on the front panel.

Normally one should only need to adjust the tuning from "Pitch Cal" One hour warm up is needed before any adjustments make sense. Of course you would normally keep the coarse and fine tune knobs at zero when performing tuning calibration.

Never touch the "Spread" trimmer when performing just basic tuning calibration. Spread is only trimmed when tubes age or when changing oscillator tubes. It determines the basic spread (the size) of octaves and should be trimmed by comparing two low notes an octave apart, for example put oscillators to 32' and play the lowest A and the octave above it and adjust to perfect octave. (Do not use the lowest notes, because as explained they are not perfectly in tune) Perform this to both oscillators separately. I usually do this by ear, I use the range switch for the oscillator I am adjusting and keep the other oscillator as a reference. i.e. I don't play different keys, only the A and change octaves from the knobs. Now, this is the somewhat confusing part:

The deionization compensation is adjusted from blue trimmers on the back side of the instrument. The left ones, looking from back. As I wrote above, this affects the highest octaves more than lowest, but also somewhat the lowest. Therefore if big changes are needed (for example when changing tubes it is recommended to check the spread from front panel trimmers once more, and then the deionization again. All these trimmers are very sensitive, so proceed with caution.

The rest of the blue trimmers on the back only affect the very highest notes of 2 foot range. The middle ones at about the second highest C (2 kHz) and the right ones the 4 highest notes.

Note that very typically the trimmers are at about those positions as in the picture below. Deionization at 12 to 3 o'clock, 2kHz range trimmer at 3 o'clock and 4kHz range trimmer at 1 or 2 o'clock. So, if you ever totally mess the system, start from these positions.

Here is a picture from the back. Top row is Osc1 and bottom row is Osc2. On the left upper corner there is a trimmer for square wave amplitude.



VCA balance

This is adjusted from two tube panel trimmers on the right. The aim is to minimize "thumps" caused by the VCA tube imbalances. Usually it is enough to adjust the "Vg2" trimmer and actually the Rk trimmer is pretty useless most of the time.

To perform the adjustment put VCA envelope knobs to near minimum and mixer volumes to minimum and play a note to hear just the VCA thump. Now adjust the sound to minimum with the Vg2 trimmer. If an acceptable level is not achieved, tubes might be too old. Replace and try again. You can also try to adjust the Rk trimmer a couple of revs to one direction, repeating the Vg2 trimming. Sometimes it helps.

Osc1 and Osc2

Octave switch: It needs to be pointed out that 64-foot position uses a different capacitor in the oscillator circuit and therefore needs to be used with "caution", for example fine tuning is needed and one should use it for really low notes only. On the other hand 32-foot position is not recommended for below 30 Hz synthesis, the tuning is not good there, therefore 64-foot is needed.

Do not expect 2-foot position to perform with accuracy and stability to the highest notes. The deionization time changes in oscillator tubes and particularly increased anode dissipation at high frequencies makes it impossible to obtain true tuning stability above 2kHz notes for very long periods of time. However this B batch of Knifoniums is much better than the first one in this respect. Calibration is faster and stability better.

There are small switches on the front panel for keyboard. The keyboard is not stable for very long periods of time if not played, the note value in memory drifts, therefore should be disengaged if not in use. Also if you want to leave synth on unplayed for very long periods, it is recommended to switch KB off.

Sync switch operates in a very special fashion and one side effect is that it lowers the frequency of the synced osc 1 by a semitone. This has been compensated in batch B, but the side effect is that if you use modulation for the sync, you will need to adjust the tuning.

There are trimmers for adjusting the sine waveforms on the tube panel. If the levels are too low the waveform is just triangle, if too high it gets too much square. Note that Sine waveforms are imperfect. They are produced from triangle with crude wave shaping.

Square wave is also quite funny if looking from a scope. It is produced by clipping sawtooth a lot. There is a trimmer on the back. Level should be adjusted so that symmetry goes properly to the extremes but does not cut the signal totally. Note that there is "extra" on the knob because when combined with other modulations it is needed.

Note that OSC 1 and 2 Modulation level does not affect feedback modulation (or, of course, the joystick X axle)

Noise

Noise is generated by a 2D21 tube immersed in strong magnetic field. Magnet position may need some tweaking sometimes and most of the times when tube is changed. Different noise colours are filtered from the white noise the tube produces. Magnet position affects the noise quite a lot too, but the position should be such that the noise starts without tweaking when synth is powered up.

Mixer

Since filter, which follows mixer, has a wide and usable overload margin, the mixer levels affect tone a lot. Start at "5" and note how filter gets more nonlinear at higher settings and how resonance decreases. Tweaking levels is very, very central part of Knifonium's sound and wild levels with resonance create very interesting timbres.

Three of the 5 mixer channels can be modulated. Opto-isolators are used for this, and they cause the channel to be off without modulation by shunting the signal to ground after the level potentiometer.

Note that due to the time constants in the optocouplers the "feel" of these modulations is a bit slow.

Filter

In case filter behaviour does not feel right, there are trimmers on the front panel for scaling and frequency.

Do not expect linear freq behaviour. For example playing with the filter self resonance with KB tracking the area in which it is in tune is limited, it will not follow KB accurately over several octaves.

KB tracking goes over 1:1.

Resonance range might first seem to be too wide, and only the range 1-6 needed, but this changes when levels into filter are increased. More resonance needs to be dialled in because of the reduced headroom in the filter. One needs time to learn the behaviour.

Note that if you switch "filter res" on from the after touch panel the resonance is turned OFF, and gradually brought in with increasing aftertouch up to the level set from the resonance potentiometer.

LFO

One thing to mention is the "bug" that causes speed to change if speed dial is above 5 and symmetry is adjusted. This is due to the rather primitive design. The obvious way around this problem is to use higher speed range and lower speed dial setting.

KB Trig will restart the LFO when engaged.

There is a separate trigger output on the LFO and therefore LFO amplitude or polarity do not affect the way LFO triggers S&H or envelopes.

When modulating LFO with Y-axle one has to switch two things on. The Y-axle destination to LFO and then either or both of the modulation possibilities from the LFO.

Envelopes

Envelopes are rather standard. Note that if you forget "gate on" on, you may be confused for a moment the next time when switching the synth on. I have been.

Envelope 2 is always controlling VCA.

Velocity levels from KB can be used to scale the envelope outputs. This way volume and timbre can be made to react to velocity.

Ring modulator

Due to the "imperfect" nature of the modulator there is a wide range of timbres available. The harder the modulator is driven, the higher multiples of sum and difference frequencies will be created.

Note that transformers in Ring modulator produce some acoustic output when driven hard. This is called magnetostriction and plagues all audio transformers to some degree. Usually one does not notice it because sound is produced from some speaker system, but with Knifonium it often happens that one closes all mixer volumes and still can hear something....and then one realizes that the sound is coming from the synth itself.

VCA

"LFO to VCA" takes its input from LFO master output and therefore LFO level and polarity do affect it.

VCA "boost mode" affects the internal signal level in it, boosting by 10dB at input and attenuating ca. 10dB at output, producing some nonlinearities. Depending on the signal level from Filter the effect can be anything from inaudible to clear, but never huge.

Output amplifier

Output amp uses one single tube, E81L, and it can be switched to 3 different modes, triode, pentode and saturated pentode. Triode will usually produce the fullest and thickest sound because there is a lot of distortion but mild clipping and a lot of bass. Pentode mode uses feedback and is fairly linear until it clips and saturated pentode mode is the most non-linear, and sounds most bright and aggressive.

The output level from Knifonium can reach 30dBu and therefore a pad is often needed to be switched on. As a rule of thumb: If you want audible distortion from output stage you also need to switch pad on.

Note that one should not try to lower the output level to "consumer levels" from the master volume, because that can only make some feedthrough audible. So for example direct connection to a typical active speaker is a **bad idea**, because they are way too sensitive compared to the levels Knifonium puts out. You wont be able to explore the beautiful distortions and feedbacks without some sort of volume controller after Knifonium.

S&H

One thing to note: Remember that there may be a voltage value stored in the S&H and if destination is for example VCO pitch, it may cause confusion even if the S&H is not triggered. To clear S&H set input to external and trigger it. After this it should not make any difference what the destination is.

Keyboard and joystick

Keyboard uses optical sensors and a fairly complex network of mosfet switches. In this way the age old resistor ladder principle has been retained, and in Knifonium the resistor modules can be changed. Any tuning system is possible, as long as the order of notes is ascending. You can order special modules from us.

Keyboard is attached to the case with 3 screws from the bottom.

It is possible to alter the velocity response to slower or faster. On the back of the KB, on the PCB on the left (looking from front) there is a 3-position jumper.

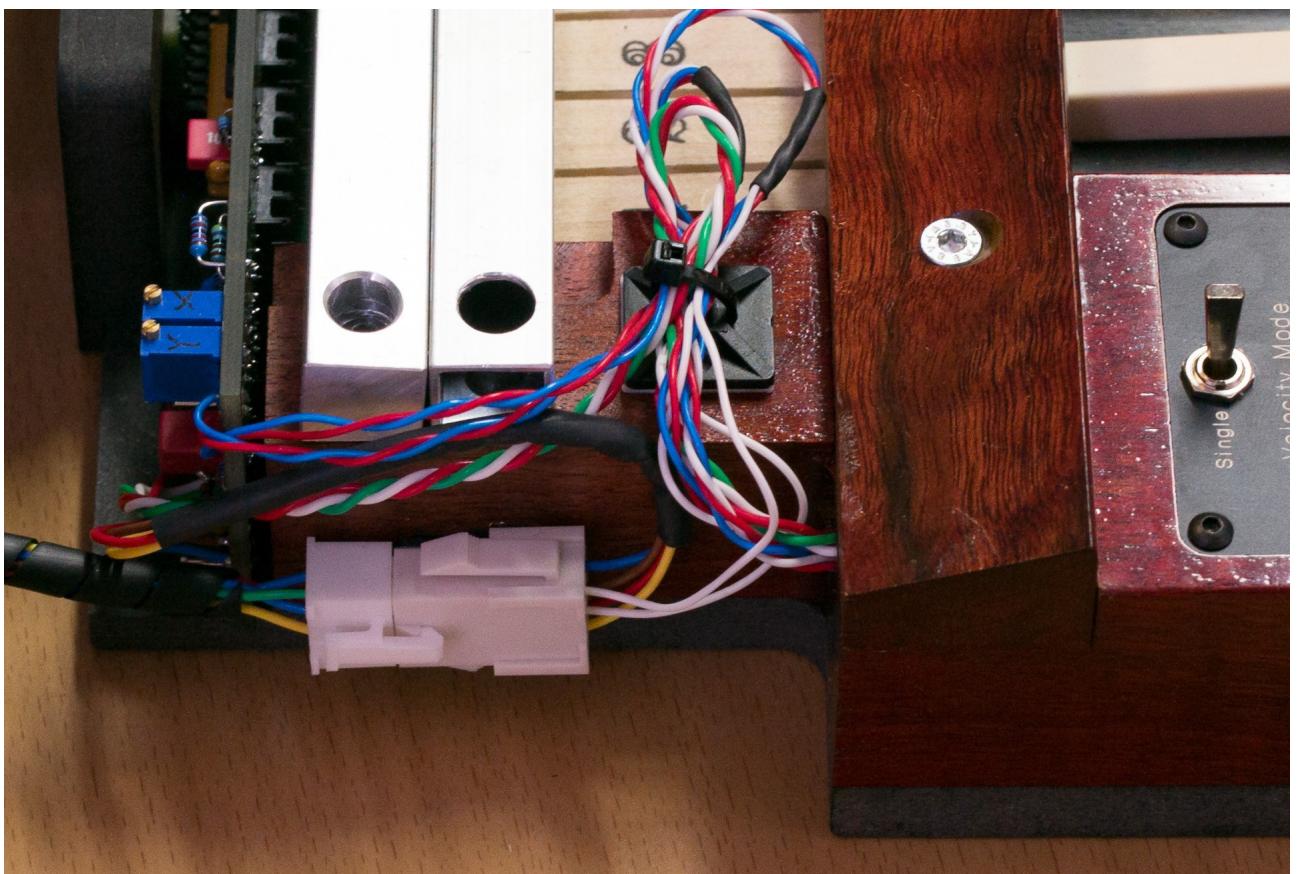
Velocity response has 2 modes. These are switched from the Joystick plate.

Multi = every key press produces a new velocity value.

Single = only articulated new notes produce a new value. Good for fast legato stuff.

Joystick can be calibrated if need arises. X and Y zeros can be adjusted from KB PCB (see picture) and scales from back of the synth (back ventilation panel needs to be removed)

The X Scaling switch has position “A”, which can be trimmed from 0 to 2 semitones. I originally made this for microtonal playing.



Aftertouch

Right KB panel has the Aftertouch switches and magnitude potentiometer. Under the panel there is a single turn trimmer (very sensitive) from which the threshold can be trimmed. We have trimmed it to be rather high, so that it is possible to play easily without producing aftertouch signal.

There is an external input for aftertouch. This was the easiest way to access many of the modulation possibilities. Engaging the switch makes KB aftertouch inactive.

Quantize produces a couple of steps.

Connectors

These generally respond to normal 1V/oct and 5V trigger standards.

-Velocity out: from ca. 2 volts to ca. 6 volts.

-Joystick X and Y out: X= +/- 5V max and Y= 0-5V. Range switch does not affect X scale.

-CV out sends 1V/oct voltage. Lowest key is 0V, highest is 3V.

-CV to VCO 1 and CV to VCO 2 inputs use normalizations to ground the lines if nothing is inserted. 1V/oct voltage

-Gate in and Gate out are a normalized insert point for KB gate output. Inserting something to Gate in cuts KB gate out.

-Sustain Ped works with closed circuit "on" pedals. It only affect VCA envelope.

-S&H trigger input. Normal primitive positive on trigger signal input.

-Audio ins: Mixer ext, S&H, Ring carrier and Ring modulator. Normal line level unbalanced high Z inputs. VCA input needs fairly high level and has only 8kOhm impedance (not a problem usually).

-Filter audio out: Very high level. Needs a passive potentiometer input in the equipment it is routed to. Otherwise clipping will occur very easily.

-CV to pulse width. About +/- 5 Volts needed for maximum effect.

-Env external gate/trigger. This can be switched from front panel for both envelopes.

-CV to VCA is 5V max normal on, but has some margin.

-CV to filter f nothing special here.

-CV to After touch external. This is somewhat weird. It can be used to "replace" KB after touch, and further routed to different destinations, for example filter resonance amount.

-Feedback in & out. In is normalized to out. This is a insert path for anything one may want to use for feedback signal processing. Delays etc can be fun. Can also be used as an extra CV input for the different destinations.

And last:

My personal favourites

I have played with Knifonium a lot, but not as much as I should have. One of my all time favourite techniques is duophonic playing combined with any kind of nonlinear things. Just switch one of the Oscillators from the KB pitch logic switches to "Off" and the other one to "On" and the note you play first stays and anything played on top of it will change. Use sync, distortions, feedback, ring modulation etc and you will have plenty of quality time before you get bored. The textures can get very interesting.

